A Compact Flip Chip Single Die WiFi FEM for Smart Phone Application

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A flip chip single die WiFi FEM is developed using Bi-FET (HBT+E/D-PHEMT) technology for smart phone application. Both solder bumps & Cu-pillar bumps were developed for the flip chip process. This FEM die consists of a high-pass filter (HPF), a 2GHz WiFi PA with on-chip regulator, PAON logic and detector circuit, and an SP3T. The HPF provides rejection for WCDMA at 2.17GHz. The 3-stage PA provides 33 dB gain with good linearity (3% EVM, 17dBm) and good efficiency (Icc=135mA @18dBm) for the FEM at the antenna port. The SP3T can be switched to connect the antenna port to the Tx port (PA output), Rx port, or BT port. A detector output is available to monitor FEM output power. The FEM is biased by a single battery supply (Vbat) from 2.3V to 4.8V. The digital command for PAON and SP3T Vcx varies from 1.6V to 2.1V.

Figure 1 shows the schematic of this flip chip FEM. The photograph of this flip chip FEM die using Cu-pillar bumps is shown in Figure 2. The die size is 1.5mmx0.9mm.

The S-parameter data of Tx mode at nominal bias (Vbat=3.3V, PAON=SP3T Vc2=1.8V) is shown in Figure 3. The FEM has 33dB Gain and better than 15 dB return loss in band. The 2.17 GHz rejection can be improved by adjusting the external high Q notch inductor. Figure 4 shows the S-parameters of both Rx and BT modes. The insertion loss is around 0.7dB (at SP3T Vc1 or Vc3=1.8V) and return losses are better than 15dB in band.

Figure 5 shows the EVM/Icc vs Pout of the flip chip FEM at 2.412-2.484GHz. EVM is less than 3% up to Pout=17dBm. It has Icq=72mA and Icc=135mA @18dBm at Vcc=+3.3V. The Detector output vs Pout plot over Vbat=2.7V-4.8V and over digital command PAON=SP3T Vc2=1.6V-2.0V variations is shown in Figure 6. The detector output is tightly bunched over bias supply variations.

Excellent EVM and Icc and Det-out over temperature data (at Cold -25°C, Room Temp and Hot +85°C) are shown in Figures 7 & 8.

A modified version of this flip chip FEM integrates a balun at the Rx port to eliminate the need for an external balun. It also includes a coupler + detector circuit at the antenna port to minimize detector output changes due to antenna VSWR variations.

In summary, we have developed a flip chip WiFi FEM die with good performance. A complete WiFi RF FEM including SAW filter (between SP3T & Antenna, for rejection at WCDMA 2.17GHz and Harmonics), Flip Chip IC, Rx Balun, Coupler-Detector and SMD R, L, C parts with module size less than 4x4x1mm is in development for Smart Phone application. The wire bond process and wire bond pads are eliminated. This Flip Chip FEM die enables size and cost reduction for Smart Phone.

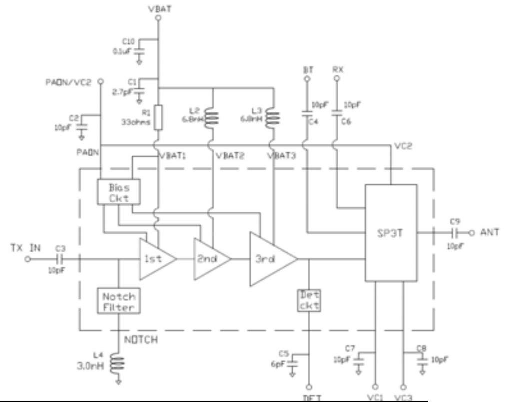

Fig 1: Flip Chip FEM Schematics

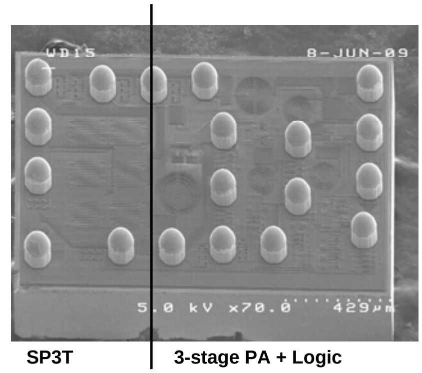

Fig 2: Flip Chip FEM Die Photo, 1.5mmx0.9mm

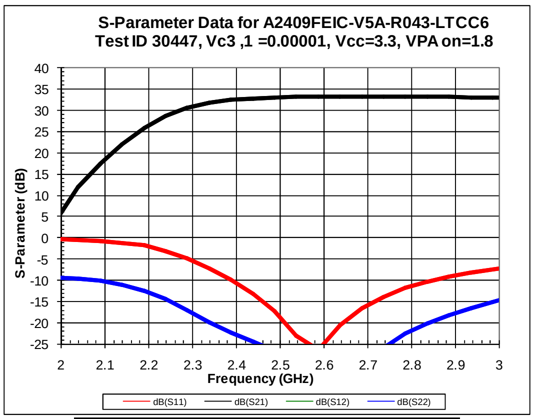

Fig 3: Tx Mode S21/S11/S22

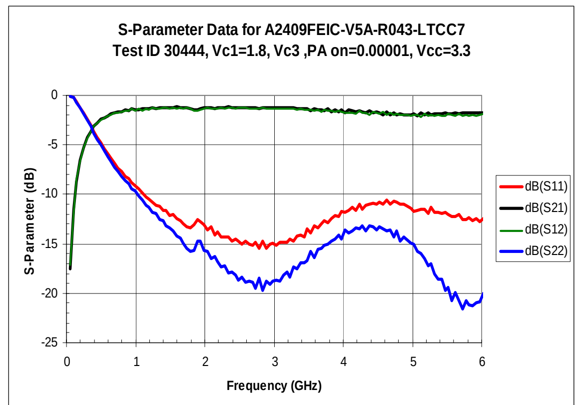

Fig 4: Rx & BT Mode S21/S11/S22

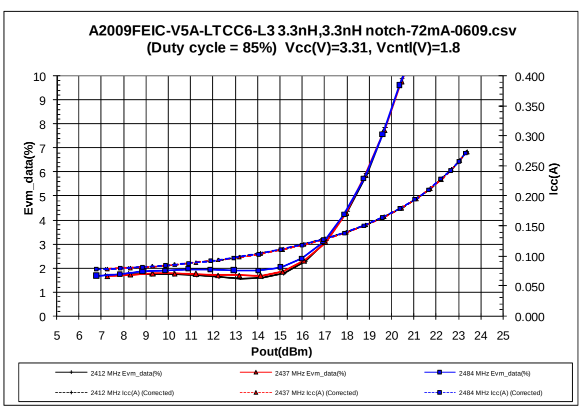

Fig 5: Tx Mode EVM/Icc vs Pout, Over Freq, at RT

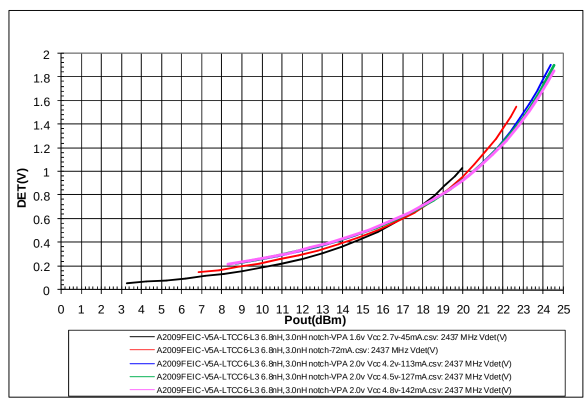

Fig 6: Tx Mode Det-out vs Pout, Over Bias Supplies, at RT

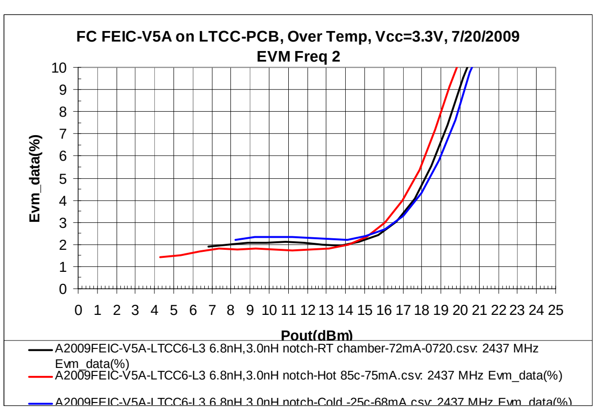

Fig 7: Tx Mode EVM vs Pout, Over Temp, at 2.437GHz

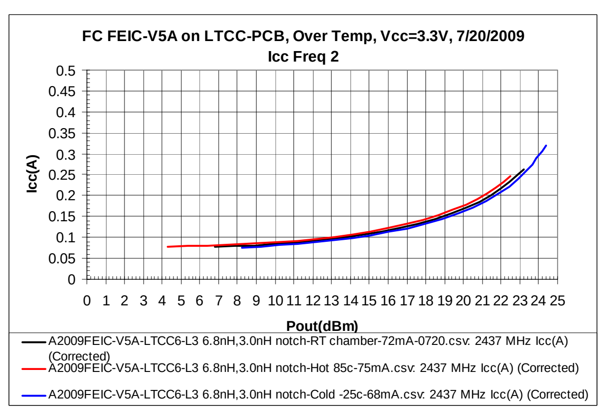

Fig 8: Tx Mode Icc vs Pout, Over Temp, at 2.437GHz